

QUADRENNIAL ENERGY REVIEW ACT

HEARING BEFORE THE COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE ONE HUNDRED TWELFTH CONGRESS

FIRST SESSION

TO

RECEIVE TESTIMONY ON THE DEPARTMENT OF ENERGY'S QUADRENNIAL TECHNOLOGY REVIEW (QTR) AND TWO BILLS PENDING BEFORE THE COMMITTEE: S. 1703—QUADRENNIAL ENERGY REVIEW ACT OF 2011, AND S. 1807—ENERGY RESEARCH AND DEVELOPMENT COORDINATION ACT OF 2011

NOVEMBER 15, 2011



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QUADRENNIAL ENERGY REVIEW ACT

TUESDAY, NOVEMBER 15, 2011

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The committee met, pursuant to notice, at 10:04 a.m. in room SD-366, Dirksen Senate Office Building, Hon. Jeff Bingaman, chairman, presiding.

OPENING STATEMENT OF HON. JEFF BINGAMAN, U.S. SENATOR FROM NEW MEXICO

The CHAIRMAN. The hearing will come to order. Today, we're here to discuss innovation and energy technology and the prioritization and integration of the government's energy activities. These issues are critically important to the country's energy future and to the work of the committee. Success in the task will mean the development of environmentally responsible energy technologies that will strengthen America's competitiveness and yield increased national security through decreased energy dependence.

The private sector must, of course, play a vital role in innovation and bringing that innovation to the marketplace to address our energy needs.

But there can be no doubt that the government has and will continue to have an essential role to play as well. Reports from the President's Council of Advisors on Science and Technology, PCAST, and from the Department of Energy itself, provide significant information on these issues from the country's leading experts inside and outside the government.

PCAST has provided a report on accelerating the pace of change in energy technologies through an integrated Federal energy policy.

In addition, as recommended by the PCAST report, the Department of Energy recently completed the first of its Quadrennial Technology Reviews. This is a review intended to provide us with a framework for understanding, discussing and establishing energy-technology priorities and for advancing those priorities through the Federal budget process.

Through the review of its own programs, the Department of Energy has provided valuable insight into areas in which Federal programs are strong, as well as areas which they suggest that we are under investing.

We also will hear testimony about 2 pending bills before the committee that I believe would help ensure continued progress and understanding in addressing our nation's energy research needs. S. 1703, which Senator Pryor has introduced, would mandate that a

comprehensive review of the energy programs and technologies of the Federal Government be conducted every 4 years. I'm cosponsoring that bill. I look forward to hearing from Senator Pryor and our witnesses on that legislation.

The second bill we're discussing is S. 1807, the "Energy Research and Development Coordination Act of 2011." This is a bill I have introduced to establish an interagency planning and budget process for all of the Federal agencies involved in energy research, development and demonstration.

There can be no doubt about the urgent need for our country to address its energy challenges. We need to bring together the best minds throughout the administration as well as outside the government to work on the challenges that we face.

The bill I've introduced would create a national energy research coordinating council co-chaired by the director of the White House Office of Science and Technology Policy and the Secretary of energy that would be independent of any individual agency.

The council would include the director of the Office of Management and Budget and the heads of any agency with a budget for energy R&D that exceeds \$10 million.

The council would produce a governmentwide plan to achieve solutions to problems in energy supply, transmission and use, including associated environmental problems in the short- and the medium- and the long-term.

The council would also prepare a consolidated budget proposal and budget guidance to the agencies for each fiscal year to implement its comprehensive plan.

I believe S. 1807 would go a long way toward making our Federal energy research efforts as effective and efficient as possible, and I look forward to discussing it with our panel today as well.

In connection with our consideration of these issues, we received a written statement from the American Energy Innovation Council. This is a group of America's business executives from some of our largest companies. We met with Norm Augustine and Bill Gates and various others from that council recently.

The council brings a useful perspective on these issues and on the importance of the legislation we're considering. They support both bills. They note that technology innovation, especially in energy, is at the heart of many of the central economic, national security, competitiveness and environmental challenges that we face.

They go on to say, "As business leaders, we know firsthand how the private sector can be mobilized to attack these problems. We also know that government must play a vital role in the process."

I look forward to the discussion on these critical issues.

Let me turn to Senator Murkowski for any opening comments she has before we hear from Senator Pryor.

**STATEMENT OF HON. LISA MURKOWSKI, U.S. SENATOR
FROM ALASKA**

Senator MURKOWSKI. Thank you, Mr. Chairman, and thank you for your initiatives that we have before us this morning.

I welcome the opportunity to consider the administration's recent technology review and our bipartisan legislation to establish a Quadrennial Energy Review.

I have long believed that our nation needs to develop an energy policy that is lasting, something that can endure, a policy that won't be completely revamped every time we have a new administration that comes into office or every time Congress passes a new energy policy act. That's why I'm pleased to be a cosponsor, along with you, of S. 1703, and I appreciate the leadership of Senator Pryor in advancing this as an initiative.

This requires the Department of Energy to conduct a review every 4 years to help develop a coordinated governmentwide energy policy.

It really is somewhat surprising to recognize that we don't already have something like a QER in place. Energy is critical to almost everything that we do, and the Federal Government has implemented a wide variety of subsidies, regulations and mandates within the energy area.

But despite that, there really is no regular, high-level assessment of whether or not our policies are effective and whether they can be consolidated, improved or even repealed.

Given the challenges that I think that we face today, it seems more appropriate than ever that we require something like the QER.

Of course, I recognize that conducting an interagency study and actually putting a long-term policy in place are 2 very different challenges, and that's why any study or any plan must involve all parties from the start. If there's not buy-in across the political aisle from Capitol Hill to the White House, from industry and NGO's alike, there's little chance that the review will help generate a long-term strategy that can survive the administrations and new Congresses.

I have also long advocated that the government should not pick winners and losers when it comes to new technologies. In terms of energy innovation and addressing our energy needs, there is a role for us to invest in research, absolutely, but I would suggest that in the vast majority of cases, if not in all cases, industry and the market will figure out a commercially viable solution much more quickly and efficiently than we here in the government would.

I think a good example of this is the development that we've seen in the fracking technologies to access our nation's tremendous shale-gas resources. Last week, we held a hearing here in the energy committee on the export of LNG, which very few of us would have anticipated just a few short years ago. We thought that we were going to need to be importing natural gas from foreign suppliers and not be in a position to potentially export a small portion of our expanding supply to other nations.

So as we consider a process to develop a long-term energy plan, I think that we need to keep examples like this in mind.

We can set goals for our energy technologies, current and future, and we can lay out a stable statutory and regulatory environment to achieve those goals, but there is a limit to what we can do. There is a limit to the effect that government can have, and, from time to time, there will be developments, perhaps unexpected developments, that require us to reevaluate our strategy and our policies.

Mr. Chairman, I'm hopeful that today's hearing will reinforce the need for a QER and highlight its importance to the formation of a truly balanced and long-term energy policy.

Thank you, again, for scheduling the hearing and I look forward to hearing from witnesses. Again, thank you to Senator Pryor.

The CHAIRMAN. Thank you very much.

Senator Pryor, we're glad to have you before the committee to describe and discuss your legislation as S. 1703. As Senator Murkowski indicated, we both strongly support your efforts, so please go ahead, and maybe we can persuade Senator Franken to be a co-sponsor. That would be good.

Senator FRANKEN. Thank you. I require a lot——

The CHAIRMAN. All right. We'll work on him.

Go right ahead, Senator Pryor.

**STATEMENT OF HON. MARK L. PRYOR, U.S. SENATOR
FROM ARKANSAS**

Senator PRYOR. Thank you, Mr. Chairman, and thank you for having me here today, and thank you both for your very kind words about S. 1703.

I appreciate the opportunity to present the Quadrennial Energy Review Act of 2011 before this committee.

You don't see a lot of bipartisan support for legislation these days, yet we have a different story to tell here today.

I believe it's because we can all recognize the need for a long-term energy strategy and we can all foresee the economic and security risks that lie ahead for America without one.

I especially want to thank Chairman Bingaman and Ranking Member Murkowski for their original co-sponsorship, as well as Senators Coons, Baggage, Burr, Alexander and Tester.

I am optimistic about our energy future. Time and again, America has shown her ability to seize opportunities when they present themselves and to create them when they do not. I'm convinced America can develop and deploy new energy technologies that are more efficient, clean and enhance our national security.

In my State of Arkansas, we're leading the Nation in responsible development of our vast natural-gas reserves. We need to leverage this creativity, entrepreneurial culture and restored leadership in science and technology to spread innovation in the energy sector and spur economic growth.

Our energy needs mirror our security challenges, and the solution to meeting these needs can be addressed in a familiar fashion.

In the end, the country that best manages its energy resources will lead the 21st century and provide its people secure energy future. The U.S. needs to win the energy race, and this bill will help put us on that path.

One of the biggest gaps in Federal energy policy is the lack of an overarching vision in coordination among Federal agencies to define how the United States produces and uses energy. Every president since Richard Nixon has called for America's independence from oil. We also need to make sure that our nation has a 21st century electric grid and matches supply with demand.

If we want to create a more secure energy future for America, then we need to develop a national energy plan that coordinates

and integrates the energy policies of the various Federal agencies. The development of such a policy would enhance our energy security, create jobs and mitigate environmental harm.

Secretary of Energy Steven Chu recognizes this challenge. In 2009, he tasked the President's Council of Advisors on Science and Technology, PCAST, with identifying and recommending ways to accelerate the large-scale transformation of energy production, delivery and use.

Led by Dr. Moniz, who is here today, one of PCAST's most important recommendations was for the administration to establish a new process that can force a more coordinated and robust Federal energy policy, a major piece of which is advancing energy innovation.

The report recommends, "The president should establish a quadrennial energy review process that will provide a multiyear roadmap that lays out in integrated view of short, intermediate and long-term energy objectives, outlines legislative proposals to Congress, puts forward anticipated executive actions coordinated across multiple agencies and identifies resource requirements for the development and implementation of energy technologies."

Last year, the American Energy Innovation Council sounded a similar call. This group of prominent business leaders came together to call for a more vigorous public- and private-sector commitment to energy innovation. Its members include former and current high-ranking executives from Lockheed Martin, Xerox, Microsoft, Bank of America, DuPont, GE and Cummins.

Their recent report, *Catalyzing American Ingenuity*, noted, and, again, I quote, "The nation needs a robust energy plan to serve as a strategic technology and policy roadmap. We support DOE's Quadrennial Technology Review, which we see as an important and meaningful first step toward developing a national energy strategy. The Federal Government should build on the QTR and move quickly toward a governmentwide QER."

Our legislation specifically addresses these recommendations and is modeled after the highly regarded Quadrennial Defense Review. The QDR is a legislatively mandated review of defense strategy priorities and sets a long-term course for the Department of Defense to assess the changing defense threats and challenges that our nation faces. It is my hope that the Quadrennial Energy Review can do the same for our national energy programs.

As the lead agency in support of energy, science and technology innovation, the Department of Energy has taken a first step to develop a national energy plan by conducting a Quadrennial Technology Review of the energy, technology policies and programs of the department.

The QTR serves as the basis for DOE's coordination with other agencies and on other programs for which the department has a key role. I commend Dr. Koonin, who's also here today, for leading the QTR, and I look forward to his testimony today.

The next step is to build upon DOE's report and perform a Quadrennial Energy Review. The QER would establish governmentwide energy objectives, coordinate actions across Federal agencies and provide a strong analytical base for Federal energy policy decisions.

The review can significantly contribute to the development of a national energy plan. It would provide an in-depth assessment of energy end-use sectors, whether they are buildings, industrial facilities, transportation, electric power or agriculture, and the policy choices for increasing our domestic-energy production.

The review would also assess our energy-supply options and evaluate how we store, transmit and distribute energy across the country.

Our bill, the “Quadrennial Energy Review Act of 2011,” would authorize the president to establish an interagency working group of senior-level government officials to submit a quadrennial energy review to Congress by February 1, 2014, and every 4 years thereafter.

The group would be co-chaired by the secretary of energy and the director of the Office of Science and Technology Policy.

With the QER, we can achieve the bipartisan goals of creating jobs, increasing domestic energy production and producing enhanced energy security while moving America toward a cleaner and healthier environment.

Thank you again for the opportunity to present this bill. I’ll look forward to working with the committee on its passage.

[The prepared statement of Senator Pryor follows:]

PREPARED STATEMENT OF HON. MARK L. PRYOR, U.S. SENATOR FROM ARKANSAS

ON S. 1703

Chairman Bingaman, Ranking Member Murkowski and Members of the Committee:

Thank you for having me here today. I appreciate the opportunity to present the Quadrennial Energy Review Act of 2011 before this committee. You don’t see a lot of bipartisan support for legislation these days. Yet we have a different story to tell here today. I believe it’s because we can all recognize the need for a long-term energy strategy, and we can all foresee the economic and security risks that lie ahead for America without one. I especially want to thank Chairman Bingaman and Ranking Member Murkowski for their original co-sponsorship, as well as Senators Coons, Begich, Burr, Tester and Alexander.

I am optimistic about our energy future. Time and again, America has shown her ability to seize opportunities when they present themselves and to create them when they do not. I am convinced American can develop and deploy new energy technologies that are more efficient, clean and enhance our national security. In my State of Arkansas, we are leading the nation in the responsible development of our vast natural gas reserves. We need to leverage this creativity, entrepreneurial culture, and a restored leadership in science and technology to spread innovation in the energy sector and spur economic growth.

Our energy needs mirror our security challenges, and the solution to meeting these needs can be addressed in a similar fashion. In the end, the country that best manages its energy resources will lead the 21st century and provide its people a secure energy future. The U.S. needs to win the energy race and this bill will help put us on that path.

One of the biggest gaps in federal energy policy is the lack of an overarching vision and coordination among federal agencies to define how the United States produces and uses energy. Every president since Richard Nixon has called for America’s independence from oil. We also need to make sure that our nation has a 21st century electric grid that matches supply with demand. If we want to create a more secure energy future for America, then we need to develop a national energy plan that coordinates and integrates the energy policies of the various federal agencies. The development of such a policy would enhance our energy security, create jobs and mitigate environmental harm.

Secretary of Energy Steven Chu recognizes this challenge. In 2009, he tasked the President’s Council of Advisors on Science and Technology (PCAST) with identifying and recommending ways to accelerate the transformation of energy production, de-

livery, and use. Led by Dr. Moniz, one of PCAST's most important recommendations was for the Administration to establish a new process that can forge a more coordinated and robust Federal energy policy, a major piece of which is advancing energy innovation. The report recommends:

"The President should establish a Quadrennial Energy Review process that will provide a multiyear roadmap that lays out an integrated view of short-, intermediate-, and long-term energy objectives; outlines legislative proposals to Congress; puts forward anticipated Executive actions coordinated across multiple agencies; and identifies resource requirements for the development and implementation of energy technologies."

Last year, the American Energy Innovation Council sounded a similar call. This group of prominent business leaders came together to call for a more vigorous public and private sector commitment to energy innovation. Its members include former and current high-ranking executives from Lockheed Martin, Xerox, Microsoft, Bank of America, DuPont, GE and Cummins, Inc. Their recent report, *Catalyzing American Ingenuity*, noted:

"The nation needs a robust National Energy Plan to serve as a strategic technology and policy roadmap. We support DOE's Quadrennial Technology Review, which we see as an important and meaningful first step toward developing a national energy strategy. The federal government should build on the QTR and move quickly toward a government-wide QER."

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As the lead agency in support of energy science and technology innovation, the Department of Energy has taken the first step to developing a national energy plan by conducting a Quadrennial Technology Review of the energy technology policies and programs of the Department. The QTR serves as the basis for DOE's coordination with other agencies and on other programs for which the Department has a key role. I commend Dr. Koonin for leading the QTR and I look forward to his testimony today.

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Our bill, the Quadrennial Energy Review Act of 2011, would authorize the President to establish an Interagency Working Group of senior level government officials to submit a Quadrennial Energy Review to Congress by February 1, 2014, and every 4 years thereafter. The Group would be co-chaired by the Secretary of Energy and the Director of the Office of Science and Technology Policy.

With the Quadrennial Energy Review, we can achieve the bipartisan goals of creating jobs, increasing domestic energy production, and providing enhanced energy security, while moving America toward a cleaner and healthier environment. Thank you again for the opportunity to present this bill and I look forward to working with the Committee on its passage.

The CHAIRMAN. Thank you for taking the initiative to introduce this in this Congress and we look forward to working with you.

Senator PRYOR. Thank you. Thank you very much.

The CHAIRMAN. So thank you. I appreciate it.

We have a second panel, which is made up of Dr. Steven Koonin, who is Undersecretary for Science in the Department of Energy, and Dr. Ernest Moniz, who is the Director of the MIT Energy Initiative, and, of course, a professor of physics and engineering systems at MIT.

Let me just say very briefly, Dr. Koonin was the leader in preparation of this Quadrennial Technology Review that we are dis-

cussing today. He also recently announced he will be stepping down from his position at the Department of Energy. I'd like to take the opportunity to thank him not just for being here today and for the work on this Quadrennial Technology Review, but also for his service, more generally, and his contributions to energy policy and research here in the Department of Energy.

I'd also, of course, like to welcome Dr. Ernie Moniz, who's a regular witness before our committee. As he probably is well aware, he is a member of the President's Council of Advisors on Science and Technology, was one of the co-chairs of PCAST's Energy Technology Innovation System Working Group.

So these are the right people to talk to us. We will, of course, make your full statements a part of our record, and we would like you to each take 6 or 8 minutes and just give us the main points you think we need to understand, and then we will, obviously, have some questions.

Dr. Koonin, why don't you begin?

**STATEMENT OF STEVEN E. KOONIN, UNDER SECRETARY FOR
SCIENCE, DEPARTMENT OF ENERGY**

Mr. KOONIN. Chairman Bingaman, Ranking Member Murkowski and members of the committee, I'm pleased to be here today to discuss the Department of Energy's first Quadrennial Technology Review and proposed legislation related to it.

The QTR was focused on DOE's activities that research, develop and demonstrate energy technologies. Its goals were to define and promulgate a simple framework for non-experts to think about energy and its challenges, to explain the roles of the various players in transforming the energy system, to define a set of principles for forming the DOE portfolio of activities, and based on all of that, to give broad guidance to the DOE portfolio.

The report on the Quadrennial Technology Review was issued on September 27th, and its companion Technology Assessments, which we have here, will be released shortly, pending final clearance from OMB. I believe that the process of the QTR, as well as its substance, will be of interest to this hearing.

Our energy challenges are several and longstanding, with energy security, economic wellbeing and environmental impacts foremost among them. Structural features of our energy circumstances condition the range and nature of solutions we can imagine. Energy is big and expensive, comprising 8 percent of GDP. Its capital-intensive infrastructure lasts for decades. So the phrase "energy revolution" is problematic.

The commodities from the supply side, electrical power and fuel molecules, must satisfy a diversity of demands. The challenges of the transport sector are quite separate from those of the stationary sector. We will not change the price at the pump by deploying more clean power.

The QTR analyses all of that and recommends 6 strategies. In transport, we must increase conventional vehicle efficiency, progressively electrify autos and light trucks and deploy alternative hydrocarbon fuels for heavy trucks. In stationary energy, we must improve building and industrial efficiency, modernize the electrical grid and deploy clean power.

Those 6 strategies are both necessary and sufficient to address our energy problems. Executing each of them will involve a mix of policies, economics and technologies. The QTR has focused on the technologies through their demonstration. It does not deal with commercialization or deployment issues. Among the QTR's more salient observations are the following:

Given that our resources are limited and the challenges urgent, we have to be strategic in forming the DOE's portfolio. To do so, we have to rise above the advocacy and ideology that plague energy technology discussions. I don't know if "fuelism" is a word but it should be

We have to focus on "solving the problems." Greatest effort should be given to technologies that can make a difference, soon, so that a technology's maturity, materiality and market potential are the most important criteria. We must encourage revolutionary technology advances, but our plans cannot rely on them.

Second, a strong program in basic scientific and fundamental engineering research underpins energy technology work. Particularly important areas are materials, biology and simulation.

Third, DOE's agenda-setting, convening, regulatory and informational roles can be very effective catalysts of energy transformation, quite distinct from the large demonstrations that the Department has undertaken in the past. They are also less costly.

Many of the barriers to energy transformation are societal, not technical. Collectively, we need to integrate social science, business thinking and policy with technology development and demonstration.

In that regard, I draw your attention to a report that's being released today by the American Academy of Arts and Sciences "Beyond Technology: Strengthening Energy Policy Through Social Science", that describes a program of social science work relevant to our energy challenges.

Next, DOE's energy technologies portfolio currently overweights the stationary sector, particularly clean power technologies, which account for half of our technology budget. An increased emphasis on transport problems is warranted, given their greater urgency and multiple impacts.

Because energy is ubiquitous, equities and authorities are spread across the government and, in fact, across society. Coordination in policy is essential—as has already been noted this morning—across both the executive and legislative branches, with the State and local authorities, and with the private sector.

Because the natural timescales for energy change are decades, policy, budgets and programs must be consistent if they are to have any significant impact. There are organizational and process changes that we can make across the Federal Government to ensure that our energy policies have the focus and consistency comparable to what we do in national security.

One obvious follow-on exercise to the QTR would be for the DOE to regularly improve, refine and update the kind of synthetic technology analysis we've attempted. Important to doing that will be to establish an enduring energy technology planning and analysis function in the department. It would also be relatively straightforward to extend such work to energy technologies across multiple

agencies, as is contemplated in one of the bills you're discussing today.

However, as you think about the broader QER, I would urge some caution. One of the reasons the QTR turned out as well as it did was that we thought through the goals, the framing and the process before beginning execution. A QER dealing with technology and policy will be far more complex with many possible goals and many more participants.

I don't believe that we know how to do it right at the moment, and, because it needs to be done right, it should not be done in haste. Structuring and organizing the interagency effort will require flexibility the first time through, and no doubt there will be a lot of learning going on. So please bear in mind as you think about legislation.

Finally, as I told the Committee during my confirmation hearing two-and-a-half years ago, one of my goals as Undersecretary for Science was to bring a more factual and rigorous analysis to energy matters. The completion of the first QTR was, I think, a good step in that direction.

With that, thanks for your attention, and I'd be happy to take questions or comments.

[The prepared statement of Mr. Koonin follows:]

STATEMENT OF STEVEN E. KOONIN, UNDER SECRETARY FOR SCIENCE, DEPARTMENT OF ENERGY, ON S. 1703 AND S. 1807

Chairman Bingaman, Ranking Member Murkowski, and Members of the Committee; thank you for the opportunity to appear here today to report on the Department of Energy's (DOE) first Quadrennial Technology Review (QTR). It has been a great honor and privilege to lead this review. Secretary Chu and I greatly appreciate your interest in it.

Access to clean, affordable, secure, and reliable energy has been a cornerstone of America's economic growth. And yet, the security of energy supplies, U.S. competitiveness, and energy's environmental impacts are long-standing challenges. All remain pressing national issues.

The President's Council of Advisors on Science and Technology (PCAST) recognized the importance of a coordinated approach to federal energy policy and called for a QTR in its November 2010 Report to the President on Accelerating the Pace of Change in Energy Technologies Through an Integrated Federal Energy Policy.¹ The Review we prepared in response sought to define a simple framework for understanding and discussing the challenges the energy system presents and to establish a shared sense of priorities among activities in the Department's energy technology programs; and to explain to the Department and its stakeholders the roles that the DOE plays in innovation and energy transformation. To holistically address our national energy technology challenges, the QTR highlights six strategies: three in the transportation sector and three in the stationary sector.

Transportation

In transportation, our challenges are energy security—each day we send \$1 billion out of the country to pay for oil—and environmental concerns over greenhouse gas emissions and other pollutants. Because oil markets are global and we import nearly 50% of our oil, we face issues with high prices and security of supply. Globally, demand for oil is growing which will continue to exert upward pressure on oil prices. Increased domestic production will allow for domestic job growth, will increase security. However, domestic production will not affect the price of oil because as a nation we cannot produce enough fast enough to significantly affect the global market. Due to the scale of OPEC's supply relative to other producers, it is able to distort the

¹Executive Office of the President-President's Council of Advisors on Science and Technology. (2010). Report to the President on Accelerating the Pace of Change in Energy Technologies Through an Integrated Federal Energy Policy, Washington, DC. Accessed at: <http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-energy-tech-report.pdf>

global market through cartel power. Other fungible liquid fuels (i.e., unconventional crude, biofuels, or gas-to-liquids) will also help reduce our dependence on oil but will be subject to the same market pressures.

Going beyond supply measures, reducing oil consumption will mitigate the impact of global oil price dynamics on the Nation's economy. Therefore, we will also reduce our crude demand through efficiency and then by progressive electrification of the light-duty fleet. Research in advanced biofuels is also necessary to supply those vehicles that cannot practically be electrified (i.e., long-haul trucks, aircraft). Our three recommended strategies, ordered by costeffectiveness and time-to-impact, are:

Vehicle Efficiency—Improving vehicle efficiency is one of the most effective short-term routes to reduced liquid fuel consumption. This has been an administration priority, as the Department of Transportation and the Environmental Protection Agency have set new Corporate Average Fuel Economy (CAFE) and greenhouse gas emissions standards for model year 2012-2016 light duty vehicles, and the President announced a framework in July for standards for MY 2017-2025 light duty vehicles. DOE will focus on internal combustion engine improvements, lightweighting, and aerodynamics. DOE's highest leverage contributions in this area include convening consortia, such as the United States Council for Automotive Research (USCAR), and providing unique facilities and capabilities in the national laboratories, such as the Combustion Research Facility.

Vehicle Electrification—Hybridization of the vehicle fleet can help reduce oil consumption at the pump in the near-and mid-term; full electrification would decouple light-duty vehicles from the global oil market. DOE will focus on batteries, electric motors, and power electronics that can improve hybrids and plug-in hybrids. DOE will maintain a limited program of fundamental research and development (R&D) in fuel cells for transportation and in hydrogen production and storage.

Alternative Hydrocarbon Fuels—Since the heavy-duty vehicle sectors face significant barriers to electrification, this part of the fleet will always rely to some extent on portable, high energy density fuels. DOE will focus on drop-in biofuels for the heavy duty vehicle, air, marine, and train markets because of the ease of deployment. The negative environmental impacts of fuels made from non-petroleum fossil fuels without carbon capture & storage currently outweigh their possible energy security benefits. We also note that compressed or liquid natural gas, although a potential alternative, would require significant investment in infrastructure.

Stationary Heat and Power

The challenges we face in the stationary sector are very different than in the transportation sector. In our residential, commercial and industrial sectors, our challenge is to provide heat and power in environmentally responsible ways that strengthen domestic innovation and manufacturing capabilities. The stationary sector is complicated by the fact that generation, transmission, and demand are interdependent. Our three recommended strategies, ordered by cost-effectiveness and time-to-impact, are:

Energy Efficiency in Buildings and Industry—Increasing energy efficiency has net economic advantages because energy expenditures decrease for the same level of service. In both buildings and industry, a lack of accessible, actionable information is a major market barrier. For building efficiency, DOE will pursue technology and information availability improvements on both a component and system level. For industrial efficiency, DOE will pursue improvements in both existing and innovative manufacturing processes.

Grid Modernization—The U.S. needs a 21st century electrical grid to provide needed stability and to integrate new forms of energy. A modernized electrical grid is essential for, among other things, wide-scale electrification of the vehicle fleet, deployment of demand response, and efficient integration of clean electricity generation. While the most critical advances needed for realization of a modernized grid are not related to technology or R&D, there are technological improvements including improving grid observation, understanding, and operation; improving control of energy and power flow; and developing and deploying energy storage that would be beneficial.

Clean Electricity—Multiple generating technologies with diverse characteristics at varying stages of maturity make it difficult to prioritize the clean electricity research portfolio. The usual metrics of potential for cost-competitive leveled cost of electricity and greenhouse gas intensity do not sufficiently differentiate among technologies. Other factors, including

modularity and scalability, water consumption, infrastructure compatibility, and global context, help to stratify the research portfolio. Comparative assessments of these factors over the full life cycle of these technology options will help ensure the cleanest and most cost-effective options for society. Above all, DOE will use the materiality, market potential, and maturity of clean electricity technologies, as described below, to prioritize its activities.

Prioritizing Our Activities

As Secretary Chu noted in his introduction to the QTR, the Department's energy technology strategy has been traditionally organized along individual program lines and based on annual budgets. With this QTR, our goal is to bind together multiple energy technologies, as well as multiple DOE energy technology programs, in the common purpose of solving our energy challenges. In addition, the QTR provides a framework to help inform our multi-year planning. Energy investments, if they are to be effective, must be consistent and flexible, multi-year—, if not multi-decade, investments.

One of the salient facts about energy technology R&D is that there are always many different technical approaches to solving the same problem—and more are being proposed every day. While a testament to the power of human ingenuity, this excess of options creates a practical problem: since we have limited resources and urgent problems to solve, how do we choose which subset of these many approaches to pursue?

The QTR has been, at its core, about developing the principles that will help inform those difficult choices between different technically viable approaches that cannot all be pursued. Mere technical promise—that something could work—is an unjustifiably low bar for the commitment of DOE R&D funds. As every dollar matters, we must give priority in our research portfolio to those technologies that are most likely to have significant impact on timescales commensurate with the urgency of national energy challenges.

The burden of oil imports and the need to reduce greenhouse gas emissions dramatically by 2050 sets a relentless clock on our actions. Because significant changes in energy supply can take 20 years or more, the Department will focus on a portfolio of technologies that can confidently be predicted to be material by 2030. Technologies can be judged by maturity, materiality, and market potential:

- **Maturity**—Technologies that have significant technical headroom yet could be demonstrated at commercial scale within a decade.
- **Materiality**—Technologies that could have a consequential impact² on meeting national energy goals in two decades.
- **Market Potential**—Technologies that could be expected to be adopted by the relevant markets, understanding that these markets are driven by economics but shaped by public policy.

Additionally, we will apply two themes to the development of the overall R&D portfolio. First, we will balance more assured activities against higher-risk transformational work to hedge against situations where reasonably assured paths become blocked by insurmountable challenges. DOE will reserve up to 20% of the Department's energy technology R&D funding for “out of the box activities”. Second, because the Department neither manufactures nor sells commercial-scale energy technologies, our work must be relevant to the private sector, which is the agent of deployment.

Furthermore, we must clearly acknowledge that even the most carefully planned energy R&D strategy can be upset by unexpected technical advances, changing market conditions, unanticipated environmental challenges, and outside events. For that reason, the QTR found that the Department should maintain a mix of analytic, assessment, and fundamental engineering research³ capabilities across a broad set of energy technology areas. Such activities in any given technology area should not imply a DOE commitment to additional demonstration or deployment activities in that area. The mix of analytic, assessment, and fundamental engineering research will vary according to the status and significance of the technology.

²We define “consequential” as roughly one Quad per year of primary energy; such a metric may not be appropriate for all technologies.

³Fundamental engineering research is research intended to understand the sensitivity of man-made systems or components to specific laws of nature. The goal of fundamental engineering research is to make better predictions about the behavior of those systems, which will broadly improve our ability to design, build, and maintain engineered products and services for particular purposes. Fundamental engineering research is an essential precursor to technology development.

Conclusions of the Review

As a result of the Review, we found that looking just at DOE:

- the Department is underinvested in the transportation sector relative to the stationary sector (energy efficiency, grid, and electric power). Within our transportation activities, we conclude that DOE should gradually increase its efforts on vehicle efficiency and electrification relative to alternative fuels.
- the Department is underinvested in activities supporting modernization of the grid and increasing building and industrial efficiency relative to those supporting development of clean electricity.

There are several other criteria to consider when balancing the energy R&D portfolio. There is tension between supporting work that industry won't, which biases the Department's portfolio toward the long-term, and the urgency of the Nation's energy challenges. The appropriate balance requires the Department to focus on accelerating innovation relevant to today's energy technologies, since such evolutionary advances are more likely to have near-to mid-term impact on the Nation's challenges. We found that too much effort in the Department is devoted to research on technologies multiple generations away from practical use at the expense of analyses, modeling and simulation or other highly relevant fundamental engineering research activities that could influence the private-sector in the nearer term.

Another important finding of this Review is that the Department impacts the energy sector and energy technology innovation through activities other than targeted technology-development initiatives—the most commonly thought-of approach for organizing DOE's effort. Public comments indicated that DOE's informational and convening roles are among its most highlyvalued activities. Information collected, analyzed, and disseminated by DOE helps shape the policy and decisions made by other governmental and private sector actors. That expertise in energy technology assessment gives DOE the standing to convene participants from the public and private sectors to coordinate collective effort. The Department's energy technology assessments are founded upon our extensive R&D capabilities. By supporting pre-competitive R&D and fundamental engineering research, DOE builds technical capabilities within universities and our national laboratories and strengthens those capabilities in the private sector.

Also heard clearly from external stakeholders was that DOE's technology development activities are not adequately informed by how consumers interact with the energy system or how firms decide about technologies. As a result, DOE will integrate an improved understanding of applied social science into its technology programs to better inform and support the Department's investments.

Fundamental to improving Departmental strategy, to implementing the outcomes from this process, and to future QTRs will be the development of strong internal capabilities for integrated technical, economic and policy analysis. The Department needs an enduring group to provide an integrated understanding of technology, markets, business, and policy for the planning and execution of technology programs. This professional group would integrate the major functions of technology assessment and cost analysis; program planning and evaluation; economic impact assessments; industry studies; and energy and technology policy analysis. Such a group would harmonize assumptions across technologies and make the analyses transparent. Previous attempts to establish such capability within the Department have resided within support offices, rather than at the leadership level, and so have had limited impact.

It is important to state that the QTR is not a substitute for the annual budget process; however, it should inform the development of those budgets as well as internal planning over a longer horizon. Further, the QTR is focused on energy technologies, but it is not, standing on its own, a national energy strategy. In March 2011, the Obama Administration released the Blueprint For A Secure Energy Future, a roadmap to guide the pursuit of key energy policy objectives, such as the President's goal of reducing oil imports by one-third by 2025.

When the PCAST, as an external advisory board to the President, recommended the QTR, it also identified its most important recommendation as the development of a multi-agency QER that would forge a more coordinated and robust federal energy policy, engaging many agencies and departments across the Executive Branch. As envisioned by the PCAST, the emphasis of the QER would be on establishing government-wide goals, and identifying the non-budgetary resources needed for the invention, translation, adoption, and diffusion of energy technologies. The PCAST found that because the responsibility for setting these goals goes well beyond the reach of the DOE, the QER would serve as a mechanism for managing this cross-cutting challenge.

I would like to briefly describe how we carried out this Quadrennial Technology Review. Public engagement was a central tenet of the QTR. Nearly 700 stakeholders supplied input over the course of the six-month review. The process began officially in March when we released the QTR Framing Document along with a Request for Information in the Federal Register. The framing document established the framework, scope, key questions, and process for the review. The QTR team received approximately 60 submissions during the 30-day public comment period. The Framing Document also served as a foundation for five stakeholder workshops across the country. Divided along the six strategies, these workshops solicited input from hundreds of energy experts from industry, national labs, academia, and government agencies. The Capstone workshop hosted in Washington, DC, in mid-July enabled us to summarize what we had learned from the public comments and topical workshops while provoking discussion on the substance of what would become our findings and conclusions. Throughout the process, the team consulted with officials within the Department, our sister federal agencies, and the Executive Office. That public and interagency engagement was vital to the quality and clarity of the final document.

DOE appreciates the support received from Congress during the QTR process as well as the interest from Chairman Bingaman and Senator Pryor in establishing a broader QER. The Administration is currently reviewing S. 1703 and S.1807 and does not have a position on the legislation at this time. The Administration is also currently reviewing its capacity to carry out a QER under existing authorities. We look forward to working with the Committee to address these important questions. Thank you and I am happy to take any questions.

The CHAIRMAN. Thank you very much for your comments.

Dr. Moniz, why don't you go ahead and give us your perspective on this set of issues, and then we will have some questions.

STATEMENT OF ERNEST J. MONIZ, CECIL AND IDA GREEN, PROFESSOR OF PHYSICS AND ENGINEERING SYSTEMS, DIRECTOR, MIT ENERGY INITIATIVE, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MA

Mr. MONIZ. Chairman Bingaman, Ranking Member Murkowski and members of the committee, thank you for the opportunity to offer views on both the Quadrennial Energy and Technology Reviews, and it's always good to be back.

I do caution that although I am a PCAST member and co-chaired the relevant working group, I testify today as a private citizen.

Reflecting on the nature of the energy enterprise, it's easy to see the challenge of accelerating change to meet pressing national economic competitiveness, environmental and security needs.

An integrated Federal energy policy up to these challenges needs staying power, and that, in turn, requires a substantive administration-Congress dialog based on clear objectives and analysis.

This is challenging in the face of multiple executive agencies and multiple congressional committees with stakes in the game, the derivative nature of energy policy and the diversity of policy instruments. The QER is intended to facilitate this dialog within the reality of this complexity.

Key organizational principles put forward by PCAST include prominent roles for the Executive Office of the President and the Department of Energy. The former has the convening power across the administration. The latter has core energy responsibilities, especially for technology, and the scale to staff a major effort.

So DOE should provide the administration-wide executive secretariat for a QER. Bills S. 1703 and S. 1807 are aligned with these organizational principles, and I support both of them in their key objectives.

The PCAST report listed objectives for the QER: An integrated view of short- and long-term objectives, legislative proposals and executive actions, resource requirements, and, very important, a strong analytical base that has not always characterized the development of energy policy.

PCAST recognized the daunting scale of such an effort, the QER—and Secretary Koonin has just referred to that—and, therefore, recommended starting with the QTR, which is mostly within the purview of DOE.

The first QTR presents processes and principles needed to prioritize portfolio choices and puts forward initial priorities.

I congratulate Secretary Chu, Under Secretary Koonin and the DOE staff for this accomplishment, and let me also add my thanks to my good and old friend, Steve Koonin, for his service in the government. The confession is that our careers have been entwined for almost 40 years.

The QTR recommendations should generate debate. They are the start of a conversation. For example, the recommendation to weigh transportation more heavily in the portfolio and then to give major emphasis specifically to vehicle efficiency and electrification over other alternatives are not universally accepted, but they were based upon a clear rationale and an argument.

A test of the QTR is whether it will, indeed, stimulate the kind of discussion that can build sufficient agreement to support long-term, stable portfolio planning with both administration and congressional endorsement.

If we return to a technology du jour approach, it will be difficult to accelerate material impact in the marketplace of the government's energy programs.

Increased energy RD&D funding is needed, and I raise that here because it would reshape the QER/QTR portfolio in important ways.

Now, clearly—and the AEIC that you mentioned earlier, Mr. Chairman, of course, has the same conclusion, but, clearly, it will be very hard to find such resources in the appropriations process, and PCAST recommended that the administration, Congress and the private sector work together on new funding streams, whose expenditure would be guided largely by industry.

Several examples within the QTR point to the importance of sustaining progress toward a full QER. For example, the QTR rightfully has a special place for efficiency, but efficiency is not the same thing as demand reduction. The latter needs integrated technology and policy, like a QER.

Another is the near absence of natural-gas discussion. While possibly understandable for a document focused on advanced technology, although our MIT report did highlight important public-private opportunities for natural gas R&D, the game-changing natural-gas story has clear implications for the clean electricity R&D portfolio. Again, a QER would incorporate that.

Another important objective of the QER would be clarity on risk-sharing mechanisms for technology adoption and diffusion. PCAST recommended starting with an inventory of existing subsidies and incentives.

Perhaps the most important near-term action to continue building the QER/QTR process is buildup of DOE capacity for energy engineering-economic analysis. I urge Congress to support this. This function could be placed in a beefed-up policy office separated from international affairs. This needs to happen in 2012 if the first QER is to be delivered early in 2014 as called for in S. 1703.

There is also a need for dramatically expanding energy economic policy and social science research at universities and NGO's. So, in addition to building up internal analytical research capacity at DOE, DOE should be authorized to provide extramural funding for such research and perhaps to partner with industry in support of a special-purpose, independent non-profit.

Finally, I return to S. 1703 and S. 1807. S. 1807 would establish the National Energy Research Coordination Council, and this would clearly be a positive development.

The QER/QTR and council processes would also be helped if we could somehow move to both 4-year congressional authorizations and more realistic DOE multiyear budget projections both aligned with a QER/QTR developed with strong congressional and non-government input.

S. 1703 would legislate a required QER, and this would clearly reinforce the PCAST recommendation, and I support that.

Two comments: The faster schedule put forward in S. 1703 relative to the PCAST recommendation I think could certainly be handled in equilibrium, but it wouldn't require, as already indicated, that 2012 be used effectively to build up DOE analytical capacity if the accelerated schedule has any chance of being met.

Second, while OSTP Director Holdren would be an outstanding co-chair, given his experience in energy technology and policy, along with the secretary of energy, I personally would still prefer that the president select the EOP leadership. This would reinforce the needed convening power from the EOP.

In conclusion, a QER would provide an important vehicle for framing a sustained, productive administration-Congress dialog, and your support and engagement will be very important for its success.

I look forward to addressing your comments and questions. Thank you.

[The prepared statement of Mr. Moniz follows:]

PREPARED STATEMENT OF ERNEST J. MONIZ, CECIL AND IDA GREEN, PROFESSOR OF PHYSICS AND ENGINEERING SYSTEMS, DIRECTOR, MIT ENERGY INITIATIVE, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MA

Chairman Bingaman, Ranking Member Murkowski, and Members of the Committee, thank you for the opportunity to offer views on the Quadrennial Energy and Technology Reviews (QER/QTR) that were recommended one year ago by the President's Council of Advisors on Science and Technology (PCAST) and on actions that this Committee might take to advance the process in concert with the Administration. Establishing the QER/QTR was the key recommendation in the PCAST Report to the President on Accelerating the Pace of Change in Energy Technologies through an Integrated Federal Energy Policy. I also thank the Committee because the fact that you are holding a hearing on the QER/QTR itself provides impetus and indicates support for the level of Administration-Congress dialog that will be needed for success of the QER/QTR. The QER is a major undertaking that will inevitably sharpen the key issues that must be addressed for a consistent, sustained and bipartisan approach to American energy technology and policy innovation.

I start by emphasizing that, although I am a member of PCAST and co-chaired the Energy Technology Innovation System Working Group, I testify today as a private citizen and not as a member of PCAST. Clearly, my views are shaped by multiple experiences and perspectives, including the PCAST working group discussions that led up to the QER recommendation; those discussions included input from many individuals in academia and labs, the private sector, and government, most notably Senator Bingaman. In addition, I was part of the Office of Science and Technology Policy (OSTP) for the scoping of and initial work on the 1997 major PCAST study on Federal Energy Research and Development for the Challenges of the 21st century, led by John Holdren, now the President's science advisor and PCAST co-chair; that report recommended a portfolio approach to DOE energy RD&D programs that remains relevant for the QTR. I then served as Undersecretary of Energy and had the opportunity to initiate portfolio and roadmapping approaches that engaged multiple stakeholders and led to some new research thrusts (large scale modeling and simulation of energy systems, electricity system reliability, . . .). In my current role as Director of the MIT Energy Initiative, I have the opportunity to work with over sixty members across the energy technology innovation chain and most closely with fifteen major energy companies that support a broad research portfolio engaging hundreds of MIT faculty and students. Finally my own research program for the last decade has centered on advancing multidisciplinary studies that link technology, analysis and policy in order to enable clean energy innovation. All of these experiences underpin the views on QER/QTR that I will summarize briefly in the testimony and in the discussion that follows.

In thinking about the need to accelerate energy technology innovation, it is useful to reflect on the nature of the energy enterprise:

- multi-trillion dollars/year revenues
- Very capital intensive
- Commodity business/ cost sensitive
- Established efficient supply chains, delivery infrastructure, and customer bases
- Essential services for all activities
- Reliability of energy delivery valued more than innovation
- Highly regulated
- Complex politics/policy driven by regional and local considerations.

This is not the prescription for an agile system that is easily transformed to meet new challenges, and indeed history tells us that many decades have been required for major changes of the energy enterprise. However, the imperative for accelerating change is real:

- for economic competitiveness, while recognizing that the U.S. will not be the principal market for new energy technology and infrastructure;
- for the environment, as prudence calls for starting to reduce greenhouse gas emissions substantially in the near and intermediate term;
- for security, by reducing oil dependence and lowering the bill for imports.

An integrated Federal energy policy up to these challenges needs staying power, and that in turn requires a bipartisan Administration-Congress dialog based on clear objectives and analysis. Substantial input from the private sector is essential, gathered in an inclusive transparent process. The governmental dialog is challenging in the face of multiple Executive agencies and multiple Congressional committees with stakes in the game. The QER is intended to facilitate the dialog.

While most decisions about new energy technology, production, delivery and use are taken in the private sector, the Federal government has crucial roles to play by investing and sharing risk along the technology innovation chain and in “setting the rules” through policies, standards, and regulations that reflect public goods. Yet, it has proved difficult to establish consistent, comprehensive and integrated Federal energy policies and programs. An “energy policy” is in many ways the sum of environmental, security, economic competitiveness, tax, land use, and other policies. And the diversity of policy instruments is just as broad: research support, technology development and demonstration, deployment incentives, government procurement, IP rules, standards and regulation, public-private and Federal-state collaboration, human resource development through education and immigration, international agreements, and more.

The QER and its derivative QTR were put forward as a way to bring more structure and transparency to the process. Key organizational principles put forward in the PCAST report lead to prominent roles for the Executive Office of the President (EOP) and for the Department of Energy (DOE). The former has the convening power to bring together the many agencies with stakes in energy and with the levers for implementation. The DOE has core energy responsibilities, especially for

technology, and the scale to staff a major effort; it would provide the QER Administration-wide Executive Secretariat. The DOE also has the breadth of industry contacts and domain knowledge needed to ground the QER in energy sector reality. The PCAST report left the decision to the President as to who in the EOP would lead the QER along with the Secretary of Energy. I will return later to specific comments on the bills S.1703 and S.1807, which are pretty well aligned with these organizational principles.

The PCAST report listed key objectives of the QER, which I repeat:

- lays out an integrated view of short-, intermediate-, and long-term objectives for Federal energy policy in the context of economic, environmental, and security priorities;
- outlines legislative proposals to Congress;
- puts forward anticipated Executive actions (programmatic, regulatory, fiscal, and so on) coordinated across multiple agencies;
- identifies resource requirements for the RD&D programs and for innovation incentive programs; and
- provides a strong analytical base.

I pay special attention to the call for an analytical basis for constructing the multiyear roadmap. This is essential for developing a resilient plan that maintains stability in the face of major events in the energy sector and changes in the political makeup of the government.

The PCAST report recognizes that a government-wide QER is a major undertaking calling for new processes and new alignments of the many departments and agencies that must work together. It is more complex than the Quadrennial Defense Review, which requires much less input from outside the department. Consequently, it was recommended that the first installment in 2011 focus on energy science and technology, which is mostly within the purview of DOE. This has been termed the QTR, and a number of characteristics were indicated in the PCAST report (where the term DOE-QER was used, rather than QTR). The first QTR builds on technology roadmapping processes that had already gone on at DOE, but importantly adds processes and principles needed to prioritize portfolio choices. It balances different energy challenges, different timescales, and different strategies. It also begins the process of establishing contact with other departments and agencies involved in energy R&D. I congratulate Secretary Chu, Undersecretary Koonin and their staffs for carrying out this first QTR and providing a clear set of priorities and a rationale that, if followed, will shift the DOE portfolio in significant ways. I would also like to thank the Undersecretary for his distinguished service at DOE, to which he brought a unique background in both academia and the energy industry.

The QTR recommendations should generate considerable discussion. In particular, the recommendation that the DOE portfolio give more weight to transportation technologies that reduce oil dependence and the subsequent priority for engine efficiency and electrification of transportation are well argued but of course will not have uniform agreement. A test of the QTR is whether it will stimulate the kind of discussion than can build sufficient agreement to support long term stable portfolio planning with both Administration and Congressional endorsement. If we return to the “technology du jour” approach of the past (e.g. the hydrogen car), it will be difficult to follow through on key programs that eventually make a material difference in the marketplace and help provide technology leadership.

Here it is important to repeat the PCAST report call for substantially higher levels of funding for energy RD&D if the economic competitiveness, environment, and security goals are to be met. There is no magic number for what Federal support should be, but numerous analyses, including those of business leaders who put together A Business Plan for America’s Energy Future, converge around a \$10B/year shortfall. Clearly the severe pressures on the Federal budget make it very unlikely that such funding could be found through the appropriations process any time soon, so PCAST recommended that the Administration, Congress and the private sector work together to explore new revenue streams based upon energy production, delivery and/or use. There are good examples of such approaches, in which the funds are managed by non-profit organizations with strong industry guidance in setting the RD&D agenda. This is relevant to the QER/QTR since portfolio design can be quite different for substantially different anticipated funding levels and mechanisms.

There are several examples within the QTR that point to the importance of placing recommendations within the broader context envisioned in a QER. For example, the QTR justifiably emphasizes the importance of efficiency for vehicles, buildings and industry. However, technological developments that increase efficiency do not necessarily equate with demand reduction. A classic example is the failure to capture the benefits of automobile engine efficiency increases as the advances were

played off against increased horsepower. This emphasizes how technology development and policy need to be integrated in order to address the ultimate policy objectives (reduced oil usage in the example above).

Another example is the near absence of mention of natural gas in the QTR, even though increased gas supply and lowered prices stimulated by shale gas development may be the prime U.S. energy gamechanger for this decade. This is understandable for an effort focused on advanced technology, although the MIT Future of Natural Gas study did point out a number of areas for which a public-private partnership should support important natural gas R&D (testimony before this Committee in July 2011). The natural gas story of bridging to a low-carbon future has significant implications for how one establishes R&D priorities for clean electricity. These considerations would be part of the broader multi-agency QER.

Another important objective for the QER would be clarity on the variety of risk-sharing mechanisms for government support of energy technology adoption and diffusion and on their application in different situations. For example, legislation since 2005 has favored up-front loan guarantees over mechanisms that reward successful project performance. An analytical approach based on historical performance would provide the basis for an Administration-Congress conversation on best practices fit to purpose. The PCAST report recommends a comprehensive cataloging of existing energy subsidies and incentives as a first step towards realignment with QER priorities.

As recognized in the QTR, there is much to do for further iteration of the QTR and for building up capacity to support a full QER. The most striking need is to build up substantial government strength in energy engineering-economic analysis as a core competence. The DOE (and its labs) have little strength in this area in comparison to the private sector, but such skills are essential for going to the next meaningful stage of the QTR. The ability to integrate technical, economic and policy analysis is in turn essential for the QER Executive Secretariat function. I urge that the Congress support buildup of this capability within the DOE. This function could be placed in an expanded Office of Policy supporting the Secretary; the PCAST report recommends establishment of a policy office separate from the international affairs function. In my view, the first QTR should be followed in 2012 by a renewed effort to build on the first edition, incorporating more analytical functions, engaging more agencies, and building momentum towards a QER that will presumably be launched more aggressively in early 2013.

Since the QER depends on strong analysis, I note that there is underinvestment in support for energy economic/policy/social science research and analysis at universities and NGOs. In addition to building up internal capability, DOE should be authorized to provide extramural funding for such research through the Office of Policy, EIA, and/or Science/BES. This need might also be addressed through establishment of an independent non-profit with core government funding, perhaps with matching funds from industry. The National Bureau of Economic Research could provide an organizational model, with research affiliates drawn from universities across the country. The QER could benefit greatly by drawing on the independent research results of such an organization.

Finally I will comment briefly on S.1703, the "Quadrennial Energy Review Act of 2011", and S.1807, the "Energy Research and Development Coordination Act of 2011". Both would have the Secretary of Energy and the Director of the Office of Science and Technology Policy in the EOP as co-chairs of multi-agency activities.

S.1807 would establish the National Energy Research Coordination Council, co-chaired as indicated above and including the OMB Director, the heads of departments and agencies with energy RD&D annual budgets in excess of \$10M, and others at the discretion of the President. It would generate an annual cross-cutting Federal energy RD&D program plan and budget proposal based on the QER/QTR. The Council would represent the agencies with input into the QTR and would codify the QTR role in guiding coordinated annual plans. It would facilitate multi-agency collaborations as appropriate, both within the Administration and in discussions with multiple Congressional committees. This would be a positive development. I make two additional observations. First, the Council might draw upon the analytical capabilities that we feel is essential for the QER Executive Secretariat. Second, the QER/QTR and Council processes would be helped enormously if Congress could adopt four-year authorizations in sync with the QER. The QER would provide an integrated government-wide roadmap that would provide a basis for Congressional discussions spanning committee jurisdictions and for a multiyear authorization. More realistic multi-year budget projections from DOE, consistent with the QER/QTR, would be an important part of the discussion. The annual appropriations process would continue in response to the Council program plans and budget proposals.

S.1703 would legislate the QER as a required submission to the Congress, providing “an integrated view of national energy objectives and Federal energy policy, including alignment of research programs, incentives, regulations, and partnerships.” Clearly this is in accord with the intentions put forward in the PCAST report. An interagency working group would be established at the beginning of each Administration, with the QER due one year later. This date is displaced by one year from that recommended by PCAST. In steady state, this shift by one year is quite reasonable. My concern is whether the first QER can be put together well by early 2014, given that the entire process needs to be invented. This can be ameliorated to some extent if the buildup of analytical capabilities and process development are funded and pursued aggressively in 2012.

The second significant difference to the PCAST recommendation is the naming of the Secretary of Energy and the OSTP Director as co-chairs. The PCAST report left selection of the EOP lead to the President. Clearly today, OSTP is headed by John Holdren, who is one of the nation’s leading energy researchers and analysts and thus well suited to being a leader in the QER development. He would be an outstanding choice. Nevertheless, I would still favor leaving the President with the discretion to choose, since the EOP convening power is very important for the QER. This is especially so since agencies with policy and regulatory equities but without appreciable science and technology programs will be key players.

In conclusion, a successful QER process would establish a new opportunity for weaving together the many threads that make up a comprehensive energy policy and for applying multiple policy instruments in a targeted way. It would also provide a vehicle for framing a productive Administration-Congress dialog on moving the U.S. towards widely-held energy economic, environmental, and security goals. The QTR is both an important first step towards the QER and a guide to constructing an energy RD&D portfolio aligned with national strategic goals. Mr. Chairman, Ranking Member Murkowski, and members of the Committee, your support for and engagement with the QER/QTR process will be important for its success.

I look forward to addressing your comments and questions.

The CHAIRMAN. Thank you both for your excellent testimony. Let me start with a few questions.

This whole issue of the QTR, the first Quadrennial Technology Review, which is what Dr. Koonin has described to us and what has now been developed, and the distinction between that and a Quadrennial Energy Review, I think is one that we really need to think about, and both of you have commented on it.

I guess that, from my perspective, a concern I would have is that if we just stick with a Quadrennial Technology Review, how do we ensure that the conclusions from that actually make their way into policy?

I think perhaps developing a Quadrennial Energy Review is much more difficult, as Dr. Koonin pointed out. But it does increase the likelihood that what we conclude in the Quadrennial Technology Review actually impacts on the policies that we follow, although it doesn’t ensure that.

So I don’t know if either of you have any additional comments on how these 2 interact and how we need to proceed.

Obviously, I think everyone agrees the Quadrennial Technology Review is a good thing. I’m just not sure it is adequate to actually cause the administration and the Congress to do what makes good sense, based on the Quadrennial Technology Review.

Dr. Koonin, did you have any thoughts on that?

Mr. KOONIN. Technology development, absent an understanding and shaping of the policy and market contexts in which it would get deployed, is not a very productive exercise.

So I think we absolutely have to bring the technology, the policy, the market environments together in a coherent picture if we’re going to make progress on the challenges that we’re facing.

So I would agree the technology review was limited in scope, both because it was what we felt we could get accomplished, barely, with the time and resources we had available, but also, it's an easier part of the problem.

The CHAIRMAN. Dr. Moniz, did you have some thoughts on this?

Mr. MONIZ. Yes, and I certainly concur with both statements. Let me just add a couple of points.

First of all, I think we should not lose sight of the fact that the QTR is, in and of itself, a positive step forward, and it also needs further development through the kind of, for example, engineering-economic capacity that remains to be built up, I think, much more strongly at DOE.

Secondly, however, its impact, as I think both of you have said, will be limited if it is not embedded in a broader policy context.

An example that I pointed out is this question of efficiency. We have historical examples, as with, for example, let's say, cafe standards, where, as the standard was increasing, technology responded also for demand reduction. But, by definition, when the standard was flat, there was no demand reduction, even though efficiency of engines kept increasing. It was just targeted at horsepower instead.

So that's where the technology is critical, but the policy is needed to make it effective in achieving our national goals.

Having said that, I will just repeat what Secretary Koonin has said and what the PCAST report said, that we should not underestimate the challenge of getting the QER right. That's why we have to be—I think we cannot afford to have 2012 pass without preparing the structures that will be needed for a successful QER.

The CHAIRMAN. OK. I think you've noted that the QTR was designed to look at the Department of Energy programs and priorities. It does not look at the broader set of issues.

Should future Quadrennial Technology Reviews be broadened beyond the DOE policies and priorities or programs and priorities, Dr. Koonin?

Mr. KOONIN. Yes, I would say, as—for example in S. 1807, it would be a good next step toward a full-blown QER. In our conversations with our interagency colleagues, there were numerous technology connections, and synergies that many people were just realizing for the first time. I think bringing all of that together under a similar comprehensive framework would be a productive thing to be doing.

The CHAIRMAN. OK. All right. Senator Murkowski.

Senator MURKOWSKI. Thank you, Mr. Chairman, and, gentlemen, thank you for your testimony here.

It sounds like, while both of you support the direction of a QER, you are both urging caution and making sure that we take the time to do this right. I think we've got some pretty good examples around here of instances where, in an effort to do something, we just kind of move forward and we may be living with a little bit of regret that we didn't take a little bit of caution. So I appreciate your testimony here today.

In my comments, I mentioned that we have a tendency around here to want to pick winners and losers. We certainly do with the technologies that are out there. Dr. Moniz, you used the term

“technology du jour,” which made me smile a little bit, but I think that’s oftentimes what happens. We see what is in favor this year. We favor it with tax credits.

We need to make sure that, as we move forward with policies we would hope to implement with a QTR, that it focuses or emphasizes the innovation in near-term technologies, but not so much in the potential, for instance, with unconventional fossil fuels, whether it’s oil, shale. We’ve got some methane hydrates that we’re very, very interested in up north.

What role, if any, do you think that DOE should play in advancing the development of these resources, again, trying to stay away from the technology du jour, stay away from that picking of winners and losers? How do we advance this? Your thoughts.

Mr. KOONIN. As we think about what the proper role of the government is in stimulating technologies, we have to look at the maturity of technologies and the capacity of the private sector to move the technologies forward.

Having spent 5 years in the oil and gas business, I know well that there are great resources within the industry that can be applied to problems as they see appropriate.

So I think, with respect to the development of unconventional, the government probably has a smaller role than it does with respect to developing technologies that are less mature and whose industries are not as robust.

Senator MURKOWSKI. Does that get you into the situation, though, where—and this is actually a point that was raised in a New York Times article recently, that DOE is essentially doing what the rest of the market has been doing in recent years, shifting from high-risk, long-term research to short-term, low-risk? Is that the direction that you see DOE going then? Go ahead.

Mr. KOONIN. Yes, we need to be solving these problems, and we can make a good start by enhancing the lower-risk, shorter-term technologies. At the same time, we need to balance that with the more speculative things, of course. But let’s get on with solving some of these problems by refining today’s technologies and getting them out there.

Senator MURKOWSKI. If it’s lower-risk, shorter-term, isn’t that an area where you would see the private sector more willing to step in then, because of that lower risk?

Mr. KOONIN. Indeed, the Department’s role there would be different. We can bring some things. Our simulation capacity, for example, can be brought to bear in engine design. I mean, engine design is a fairly mature technology. Nevertheless, the Department has certain simulation capabilities that it can use to make engines even better, and we should be working with the private sector to make that happen.

Also, in materials. High-strength, corrosion-resistant, high-temperature materials can make important, although incremental, advances in today’s technologies, and those are important things to be working on also.

Senator MURKOWSKI. Let me ask you something else and I’ll ask you, Dr. Moniz, to comment on the same question that I asked Dr. Koonin, but, also, both of you have mentioned the societal issues,

and I think you said, Dr. Koonin, that the societal problems may be a bigger issue for us than determining the technologies.

How do we really deal with that part of it? That, it seems to be much more difficult to get your arms around than figuring out how we fully build out technologies that will get us to policy goals. Dr. Moniz.

Mr. MONIZ. Thank you, Senator Murkowski. First, let me perhaps refreshingly differ a little bit from my colleague in one of his answers, specifically, the comment with regard to unconventional, and you raised methane hydrates, for example.

I will cast this as part of a theme that was just referred to as, I think, public-private partnerships are, in many ways, being underutilized effectively.

In our natural-gas report, that I testified before this committee in July on, we showed a historical example in terms of coal-bed methane, and, to a certain extent, shale, in which what was critical was that the Department of Energy had some upfront investment—reservoir characterization issues, et cetera.

Then, in those days, the Gas Research Institute, a public-private kind of partnership, then built on top of that with a stable, 12-year roadmap that developed the core technologies.

At the same time, the Congress passed an incentive for producing from the unconventional wells. The incentive would have made no difference without the technology, and the technology wouldn't have been deployed without the incentive. Very importantly, the incentive was, right from the beginning, time limited. Nobody had the view this is going to be a gravy train forever. That was extremely effective.

I think methane hydrates can be the coal-bed methane of the future if we, in fact, put together a kind of integrated roadmap of DOE, public-private and appropriate incentives. So I think that is exactly the kind of discussion that a QER would have that goes beyond a Quadrennial Technology Review.

So I would say, even in that area, there are pieces of the puzzle where the Department of Energy and public-private partnerships have a major role.

I think maybe I could stop—stop—

Senator MURKOWSKI. I appreciate it. Thank you, Mr. Chairman.

The CHAIRMAN. Senator Franken.

Mr. MONIZ. Oh, social science. Social—

The CHAIRMAN. Oh, did you want to—

Mr. MONIZ. With your permission, I forgot to go to the social science part.

The CHAIRMAN. Oh, OK. Go ahead and complete your answer then, and then we'll have—

Mr. MONIZ. I might say that, at MIT, in our energy program, the importance of integrating social science with the science and engineering work is a place where we definitely walk the talk.

Right from the beginning, our program has been organized in that way because, in agreement with what Secretary Koonin says—and the example I just gave actually in terms of the coal-bed methane, for example—technology itself will eventually, if it is good, cost-effective technology will eventually find its way into the marketplace.

But if we want to accelerate, which I think is needed in the context of our current needs of economic-competitiveness environment, especially addressing the carbon issue and security, that can only happen with the appropriate policies, the appropriate economics, the appropriate understanding of the marketplace and societal needs. We are dramatically under-investing in this area, and, frankly, it would be a pretty cheap investment compared to technology development.

So I strongly endorse the idea, and the PCAST report as well endorsed the idea that we should authorize the department to support some of this research.

The CHAIRMAN. Senator Franken.

Senator FRANKEN. Thank you, Mr. Chairman, and thank the 2 of you.

Reading the summary of the report and being in this committee for this Congress, it strikes me in many ways that there are a lot of cross currents going on here and that sometimes there's an elephant in the room that we don't quite address head on, and that is global climate change.

Ninety-seven percent of scientists who write on the subject agree that climate change is real and that it's caused by human activity. I know the president understands this, which is why he set out goals of 83 percent greenhouse reductions by 2050.

But reading what I read of this report, it feels like the climate issue is on the sidelines, like we don't want to call too much attention to it, because it's somehow controversial.

It's not very controversial. It's not controversial among scientists. The national security challenges posed by climate change are every bit as urgent as the security threats from our reliance on foreign oil.

You don't have to take it from me. You can take it from the Defense Department or the National Intelligence Council, both of which have said that climate change is a major threat to our national security.

So I'd like you to explain how you have considered the challenge of climate change when making recommendations in this QTR, because if we're electrifying our vehicle fleet, which I think we should do, but just burning coal in coal-fired plants, that gets us off foreign oil. It certainly doesn't do much to reduce greenhouse emissions.

Mr. KOONIN. So, as a general remark, first, I think your question highlights the fact that there are multiple challenges here: the oil security issue, the greenhouse gas, and, more generally, environmental problems and the economic issues, and different steps we can take will address those issues in different proportions.

I think one of the elements of the kind of discussion we need is, how do we weight those various problems? What should we be addressing first? Some may be easier than others. That's the first comment.

Senator FRANKEN. Yes, I think we have to navigate those strains of concerns, and I don't feel like we are doing that head on in this. I feel like we're skirting it out of sensitivity for some, maybe, in Congress who are, shall we say skeptics, and get their information from skeptics.

Mr. KOONIN. With respect to the report itself, there's a healthy section on clean power which is the source of 50 percent or more of U.S. emissions, greenhouse-gas emissions. I think all of the technologies that we consider in the report are low- or zero-emissions technologies.

Senator FRANKEN. OK. You know, there's so much to follow up on on that, but let me get into one thing. I know you want to talk about transport as opposed to stable stuff, but I want to talk about buildings for a second.

The president has set a goal of making non-residential buildings 20 percent more energy efficient by 2020. This will take major investments in both the public and private sectors.

The QTR notes that many of the cost-effective energy-efficiency measures available today for business and industry are not implemented, in part because it's so difficult to finance efficiency projects.

Last month, I launched an initiative called Back to Work Minnesota aiming to create jobs in our State by implementing more energy efficiency retrofits. One of the main goals of this initiative is to identify financing solutions for retrofit projects.

Do you have recommendations on how to unleash financing for energy efficiency retrofit projects in commercial—especially in commercial buildings, but also in public buildings, to deploy the efficiency technologies that are already available?

Mr. KOONIN. I'm afraid I don't have much to add to that. I mean, all of this is outside the scope of what we did in the QTR, which really went through the demonstration phase. Deployment is something that needs to be considered in a broader QER.

Senator FRANKEN. OK. We're working on that.

Mr. KOONIN. That's very good.

Senator FRANKEN. So if you are interested, my office has been working on that exactly.

OK. My time is up and I thank the chair.

Mr. KOONIN. Let me just say the example you cite of improving efficiency is a great example of the more general problem that it's the societal problems as much as it is the technology.

Senator FRANKEN. Hence, the social science.

Mr. KOONIN. Social science—

Senator FRANKEN. Dr. Moniz was talking about it.

The CHAIRMAN. Dr. Moniz, you want to comment also?

Mr. MONIZ. Senator Franken, first of all, I wanted to say that I completely endorse your statement about a stronger focus on the issues of global warming and climate change.

Senator FRANKEN. I thank you. You're a brilliant man.

Mr. MONIZ. Among the major drivers, we should point out that the one in which the clock is set by nature and not by social systems is the climate challenge, as opposed to the economic and security challenges.

Second, I believe that the argument around climate change has regrettably focused much too much on the issues around complex models and their interpretation.

Frankly, simple arithmetic tells us that we are impacting the atmosphere in material ways, and prudence, therefore, calls for us to

look at least at what you would almost call no regrets actions toward new technologies.

In fact, third, would argue that the security challenge is also about carbon, and so there are many, many synergistic responses to both climate and security.

On the buildings, I completely agree that this is a major near-term opportunity. I believe we need to go to something like, you know, energy savings contracts, in a certain sense. That's No. 1.

But, No. 2, and this is very difficult, it's extremely hard to see how we make major progress while having such a fragmented standards setting for buildings at the, frankly, even local and city level.

With that, it's very difficult to educate the trade unions, for example, in terms of the simple technologies that are available. I mean, we'd be delighted to work with you on that.

Senator FRANKEN. Oh, that'd be terrific. Thank you, Dr. Moniz.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you.

Senator Coons has agreed to allow Senator Manchin to go ahead with his questions, and so, Senator Manchin, go ahead.

Senator MANCHIN. Thank you, Mr. Chairman, and thank you, Senator Coons. I appreciate it.

Thank both of you for being here, and I appreciate very much your testimonies. Also, I've gone through some of your findings, and I appreciate that also.

My concern has always been energy independence for the security of this nation, our addiction to oil and the price that we pay in so many ways.

With that, on page 19, you'd said that, "Currently the Nation is virtually energy independent in the stationary sector. Neither natural gas nor coal—the fossil fuels most important to stationary energy—are currently traded in an integrated global market that sets a global price."

I would just say that why would we not want to use energy sources that we have an abundance today to replace that oil until we find the fuels of the future?

Let me say in my little State of West Virginia, we're doing everything we can, and I know that we're very—as you know, an extraction State and produce an awful lot of coal.

Now, we've found the natural gas, as far as our Marcellus shale. Utica shale is going to be coming on, and that's tremendous, fine opportunities for all of us.

Also, we have an abundance of coal, as you know. We have coal-to-liquids, and I know that—I've heard the arguments back and forth. We have more wind power, we have more wind farms than anyone east of the Mississippi. People don't know that. We're using every ounce of hydro that we have everywhere on the rivers. So we're willing to do what we can. We have tremendous biofuel potential.

But with that being said, I can't believe in this many—the 21st century we don't have an energy policy that's totally energy independent, and that starts with each State looking at its resources and availability.

I'll make one comment and then I'd like to have you all comment on that is we did an energy audit in the State of West Virginia. We've declared energy independence. We don't believe that we should be dependent on a drop of foreign oil.

This audit turned up showed that by May 1st of every year we're dependent on foreign oil, because of how we run our State and the dependence we have on petroleum.

With that being said, we can convert our coal to gas. We can convert a lot of our equipment now to compressed natural gas or propanes, a lot of our transportation as far as our schools and school buses and our mass transit and all those things.

We're looking at that, but we're not seeing any type of a holistic approach to how we can use what we have now because of the demonizing of the fossils, and still we're depending on more than 50 percent of fossils to carry the load until we find the fuel of the future.

I noticed there wasn't much in here about that, you know. If you could comment on that, either one. Doctor, if you would start, Dr. Koonin, and then Dr. Moniz.

Mr. KOONIN. The transport sector is the one where we have the greatest concern about foreign dependence. But I think the concern goes beyond that, and let me just take a moment to talk about some of the nuances here.

We are coupled to a global oil market. Oil is priced globally. There are some differences due to quality and location, but, basically, there is one global oil price. We are not in control of that price, as the president has said. We're a small producer and a large consumer in that global market.

We can take steps, such as increasing domestic production. You could do coal-to-liquids, if the economics were favorable, gas to liquids. All of those will produce liquid hydrocarbons that are fungible with oil, and, consequently, will continue to sell and trade at the global price.

So if we really want to free ourselves from foreign influences, we've got to get beyond energy independence to price independence. There is a difference. Let me give you an example I like to cite. If you look at the UK in the year 2000, there were fuel riots because of an increase in diesel and petrol prices driven by a global rise in oil.

At the same time, in 2000, the UK was more than energy independent. It was exporting a lot of oil. So even if we produced it all at home, which I think would be very difficult to do, we will still be subject to the dynamics of the global market.

If you want to decouple from those dynamics, free yourself from them, we need to run our transportation on something other than a liquid hydrocarbon, and that means either electricity or natural gas or hydrogen.

Senator MANCHIN. Dr. Moniz.

Mr. MONIZ. Yes, so I think this issue of oil imports is certainly a very important one, and I focus more on the dollar exports than the oil imports, personally. But I think, as was just said, implicitly, at least, I think we need to work toward that. It will take a while.

However, and this gets to, I think, to the price independence, we can, I believe—on the road to that, we can have a huge impact ear-

lier if we pursue issues of, for example, flex-fuel vehicles, where we can draw upon petroleum, biomass and natural gas feedstocks, a so-called open fuel standard that's been considered in the Congress. In our natural gas report, we urge that that open fuel standard be supported.

The idea is that if the consumer has arbitrage possibilities essentially at the pump, that removes—that completely removes the strategic value of oil and provides more of this price stability, and particularly price volatility stability. So that's a first step.

Now, I mentioned petroleum biomass and natural gas feedstocks. There is, of course, also the fourth major reservoir of carbon is the coal feedstock and coal to liquids you mentioned. There, of course, the challenge is that I personally believe that we will at some reasonable time be restricting carbon emissions, and so this brings us back to what I believe the job of the government is here. It's not to set market shares of technologies. It's to provide the options to the marketplace to choose.

A critical option in this context is carbon sequestration. It is extremely disturbing that we have not made more progress in getting this demonstrated at scale. In fact, we believe—We had a workshop on this last year together with the University of Texas. We believe, frankly, that the departmental program should be restructured explicitly around the co-benefits of enhanced oil recovery and sequestration, because, ultimately, the problem is always ultimately the cost of carbon capture.

So we need basic research to reduce that. In the meantime, we need to do something to monetize part of that cost. So that's, I think, what we should do in a more comprehensive way.

Senator MANCHIN. Thank you, sir, both of you.

The CHAIRMAN. Senator Coons.

Senator COONS. Thank you, Chairman Bingaman. Thank you for calling this hearing. I was happy to accommodate Senator Manchin. He and I are both celebrating our 1-year anniversary as Senators today. So—and I—

The CHAIRMAN. Congratulations.

Senator COONS. Thank you. It's been an interesting year, I must say.

Senator FRANKEN. My anniversary doesn't fall on the normal anniversary.

The CHAIRMAN. That's right.

Senator FRANKEN. Yes, I remember—

[Laughter.]

Senator COONS. I wanted to start simply by thanking Dr. Koonin for his service and his leadership and express my regret at hearing you're moving on from your current role within the department and look forward to hearing from you in future roles. I think you've contributed greatly to progress on the core topic of this hearing today.

I don't believe I've ever heard the word "fuelism" before, but I appreciate your ongoing efforts to expand my fairly limited lexicon of energy-related terminology.

I, you know, was struck in sort of looking over the 2 bills that are really sort of the core of focus today. The S. 1703, which Senator Pryor spoke to earlier, does enjoy bipartisan support, broad

support, and I am hopeful that out of this hearing we'll move forward with both Pryor's bill and the chairman's bill.

If you would, Dr. Koonin, just start by helping me understand some of the context here. The Quadrennial Reviews that have long been performed by the Department of Defense, and, in the current administration by the Department of State, the Quadrennial Technology Review is a DOE effort to look at technology, and the QER, which we've largely been focused on here today, is intended to bring an administration-wide look at priorities and projects.

The very interagency cooperation that would be required to make the QER possible also makes the undertaking far more complicated.

How will the DOE, as the agency in charge of coordinating the QER, deal with that complexity, ensure that the final product is useful and engage the many different entities across the administration?

Mr. KOONIN. I think that's a wonderful question. I don't think we've thought it through entirely, but I can give you my own sense of how it should be done.

The QTR process began with the good framing of the issues. What are we trying to answer? I would think that, in doing a QER, that's probably the first step. What are we trying to focus on? I don't think you can do it all the first time. You might choose to focus on transportation. You might choose to focus on greenhouse-gas emissions or some other direction just to take a bite-size chunk.

I think it's then a lot of groundwork to frame whatever issues you're trying to address, background, suggestions, and then, frankly, it's a lot of legwork out with the agencies. We did, in the course of the QTR, a lot of bilateral meetings with folks in the agencies not only to enroll them, but also to get their ideas, and I think the product was much better for that.

Then, because energy is in the hands of the private sector and the consumers, you've got to be out a lot. We used workshops in the QTR, focus groups. I think that's the way in which you can build the kind of broad consensus that Senator Murkowski was talking about in order to make something that is both sensible and has a chance of enduring.

Senator COONS. One of the things the administration has recognized is that there's a whole range of clean-energy technologies that are currently in sort of development and deployment that cross departmental lines.

For example, you know, wind, solar, geothermal on Federal lands. You've got permitting and access and approval issues, hydrokinetic, offshore wind, of particular interest to me, you've got across departmental lines, and they require significant agreement that is, at times, difficult to achieve.

Do you believe that, by undertaking the QER, we'll have a better baseline to which to refer to allow us to resolve some of these jurisdictional regulatory hurdles going forward, regardless of the technologies of focus?

Mr. KOONIN. We found, in the bilateral meetings at the senior working level, I would say, a great appetite for this kind of discussion and coordination. It's an untapped potential within the government that someone needs to exploit.

Senator COONS. Dr. Moniz, if I might just toot my Governor's horn for a moment, my home-State Governor has, I think, done a great job of leading a broad review of a state energy plan, an integrated resource plan. We have a number of, I think, innovative financing mechanisms, the sustainable utility, for example.

Energy and technology policy are obviously made at the state and regional level as well as federally. How would you envision a QER engaging states and other outside groups, non-Federal groups?

Mr. MONIZ. By the way, if I may add to your list, another issue is grids—

Senator COONS. Yes.

Mr. MONIZ [continuing]. Which has both multiple agency and multiple State issues along all the lines of your comment.

If I may add a comment with what Steve said, I mean, our view is that, while the Department of Energy must form the executive secretariat and has great convening power in the energy industry, the convening power across the government does not reside with the DOE, and that's why it must be a strong partnership with the EOP to provide that. Then if DOE builds up this powerful engineering economic analysis capacity, that will give the—to back up the framing that DOE does.

The States, as you rightfully say, the States, and also sometimes regional collections of States, have been leaders, obviously, in much of energy-policy development. The QER will not work without recognizing that. Indeed, we make a point—it's actually in my written testimony as well—that the regional—the legitimate regional differences in the United States for energy technology and energy policy and fuels must be recognized in a robust and resilient policy. Frankly, I think, for too long, we failed to recognize that and dead on arrival. So the States must play a critical role.

I would say that it goes 2 ways. The States, I think, have a tremendous amount of input to make to the process. But I must also say that, in some cases, we bear a history of organization around States like, for example, in the electricity sector. That does not reflect the physical reality of grids, for example, of moving renewable resources across many, many state boundaries.

So I think the States also must be part of the conversation and must also show the flexibility to address some of these key questions.

Senator COONS. Thank you. I see my time is up. I have other questions I might submit for the record about the Executive Office of the President and other entities and how to facilitate the objectives put forward today in this hearing.

Thank you both. Thank you very much.

The CHAIRMAN. Very good. Senator Hoeven.

Senator HOEVEN. Thank you, Mr. Chairman. Greetings to our distinguished witnesses today.

Mr. Koonin, thank you very much for coming to North Dakota yesterday for our—

Mr. KOONIN. Pleased to do so.

Senator HOEVEN. Empower North Dakota Energy Conference. Appreciate it very much and appreciate your remarks there.

The question I have for you is something that we talked about yesterday. As you saw, we had tremendous representation from all the different industry sectors at the energy expo, both traditional sources of energy, natural gas, oil, coal, as well as the renewable sectors—wind, biofuels, biomass, solar.

We talked about the different programs we have and how we have great cooperation among the different industry sectors in terms of our State's comprehensive energy policy and power in North Dakota which we've built up over the past decade.

When I had an opportunity to make some remarks, I talked about how important it is that we get the traditional sector and the renewable sector working together. If we're going to have the kind of legal and regulatory climate we need to truly develop our energy resources, to stimulate the private investment, to deploy the technology, to produce all these energy sources, we've got to get fossil and the renewable communities working together.

Tell me how we do that, how you're working at DOE as under secretary to do that and the role that technology plays in that effort, but specific ideas on how we get them working together, how you're working to do that and how the technology will help us accomplish that. These synergistic partnerships which we know are out there which we're doing, please talk about that a little bit. I'll ask the same question to Dr. Moniz, too.

Mr. KOONIN. So, first of all, thanks for helping host a wonderful day yesterday as I was getting a sense of North Dakota. As you mentioned, I was particularly impressed by the diversity of folks that were around the table—industry, NGO's, government—discussing energy matters in what I thought was a very considered and productive way.

I think one of the greatest outputs of a QER, beyond whatever document itself emerges, is a greater understanding and dialog across different parts of industry and then with industry and government and the consumer and so on.

In the QTR exercises that we have carried out to prepare this report, I think some of the greatest value was getting that kind of diversity in the room and focusing on a specific technology or set of technologies.

So I think it starts with just understanding and dialog which has been sorely absent, I think, in a lot of what we do in energy.

The second thing is that there are legitimate ways in which traditional and new energy technologies can work together by firming renewables with gas, like the fly ash example that I saw in North Dakota yesterday. I think we need to be on the lookout for those in the Department, and the government more generally, promoting them.

Senator HOEVEN. Pleased to hear you mention the fly ash, because I have legislation on that very subject, and I think it is an opportunity to bring traditional and renewable together.

The other example you gave, would you repeat that one?

Mr. KOONIN. I'm blanking right now. The Department of Energy firming renewables, right. So you can have intermittent renewables and back them up with natural gas to make sure that the power is—

Senator HOEVEN. Right. That's what I mean. I think that really is an opportunity, but I just wanted some specific—You're talking about wind and natural gas, gas-fired plants. I mean, just wanted you to give me some examples in that category.

Mr. KOONIN. So, you know, the beneficial use of carbon dioxide to enhance oil recovery—

Senator HOEVEN. Exactly.

Mr. KOONIN [continuing]. Is another kind of—

Senator HOEVEN. Something that we're very interested in doing.

Mr. KOONIN. Right. Right.

Senator HOEVEN. We need you to help drive that process with your programs.

Mr. KOONIN. Right.

Senator HOEVEN. We have that opportunity, both with carbon capture, thorough our—not only our traditional coal-fired electric, but gasification plants, and, of course, the proximity to oil fields.

Mr. KOONIN. As for all beneficial uses of carbon dioxide, though, I would urge a little bit of tempering of enthusiasm. The U.S. used a total of 60-million tons of carbon dioxide last year from other sources for enhanced oil recovery. That amounts to just about 1 percent of the U.S. CO₂ emissions. So even if we doubled or tripled that, it still is a small bite out of a much bigger problem.

Senator HOEVEN. The same challenge that we had in producing oil out of the Bakken with horizontal drilling. When we started, it was not economic to do that. It is not economic to do carbon capture and sequestration, even though we've got all the elements—

Mr. KOONIN. Yes.

Senator HOEVEN. This is where we need the technology to help drive the process by driving the cost down, the efficiency higher.

Your programs are key here. Again, we need to go back to your original comment, the dialog, we have got to engage both communities, the traditional and the renewable sectors in this discussion where they both perceive a victory, and that's not happening.

Mr. KOONIN. No.

Senator HOEVEN. We've got to somehow drive that in Congress, but we need your help. I think that technology is a big, big factor in helping make that happen.

Mr. KOONIN. As I said, I think the QER could be an important catalyst and forum for that dialog.

Senator HOEVEN. Mr. Chairman, if I could beg your indulgence for another several minutes.

Doctor, would you—and, again, if you can drill in on some specific examples, maybe that helps us move the dialog forward.

Mr. MONIZ. Sure. I should congratulate you on your State's energy economy. It's booming.

But let me pick up exactly on these examples. I would differ a little bit with Secretary Koonin's statement on the EOR. In fact, I think before you arrived I commented that we have advocated that the department's program be restructured explicitly around the co-benefits of enhanced oil recovery and carbon storage. Largely for the reasons you expressed, we need to do something to offset the costs of carbon capture if we are to demonstrate large-scale storage, and, of course, having more domestic production is a benefit.

Today, as was stated, there are about 60-million tons of CO₂ being used to produce around 300,000 barrels a day in the United States. The estimates are that this won't happen quickly, but over about 20 years, that could go up roughly 10 X, potentially, to about 3-million barrels a day, which would be a pretty substantial contribution in 20 years.

That would then soak up approximately 20 percent of the CO₂ from coal plants, and, bluntly, that may be about the limit of credible retrofit of our coal fleet. So there may be a very good match between what we can do with retrofits and enhanced oil recovery.

The key, however, ultimately, is new technology for carbon capture that reduces the cost not incrementally, but by factors of 2 or 3 or pi. I believe that will not come from incremental improvements around today's technology, the so-called amine capture.

This is where we need a parallel program demonstrating the storage and doing a lot of basic research and some wild ideas about what could be effective—reductions in cost.

On the renewable and gas, another very, very important issue, let me say that that's a case where the challenge today is probably less on new technology and much more on the policy and regulatory structures.

For example, if we're going to balance, let's say, wind with gas, we may very well be requiring gas plants that are used at rather low capacity factors. So we also need a regulatory structure that pays somebody to build capacity and not just to produce kilowatt hours. So that's where the technology and the policy come together, and the States will play a huge role in that.

Senator HOEVEN. The key is figuring out how you work with markets to drive that process in a cost-effective way.

Back to your first example for just a minute—if I could have just a couple more minutes, Mr. Chairman—for example, in North Dakota, we have the elements to do the carbon capture and sequestration process, because you have both the coal, we have both, again, electricity and gasification where we actually produce—

Mr. MONIZ. Yes, Great Plains, yes.

Senator HOEVEN [continuing]. Synthetic natural—Exactly.

In proximity to oil fields that have both the maturity—The Weyburn field, for example, in Canada, which has the maturity, but also the density, the—you know, a lot of wells in close proximity.

The nature of the Bakken is such, over this next X number of years, we're going to be doing a lot of infield drilling. So you're going to end up with mature fields with a lot of wells close together, which works with sequestration.

So what I'm saying is this is fertile ground to do exactly what you just described in terms of that technology development and deployment to make this commercially viable.

If we make it commercially viable, that is how you are truly going to capture CO₂, not through a policy ordering somebody to do it when it's not economic, not just for this country, but for other countries, too, because they'll see that it's a cost-effective proposition.

So what I'm saying is that's a very fertile place for the DOE to really go to work and figure this out.

Mr. MONIZ. Again, I agree with that. Although, I do feel, in the end, it would be a combination of the EOR value plus some kind of carbon pricing that would make it a large-scale commercial enterprise.

But I would just also add that when we advocate exactly what you're calling for, a more organized approach around EOR, this is not just about saying the project will do EOR. It's about a much more comprehensive planning around what is a CO₂ transportation infrastructure. How do you assign liabilities? How do you share the rent between the CO₂ producer and the enhanced oil recovery? So it needs a very different kind of program design.

Senator HOEVEN. In our State, we've utilized the Interstate Oil and Gas Compact Commission model to put a legal and regulatory structure in place to address liability issues.

Final point is I would be interested in both cases, both with the carbon capture and sequestration and this marriage between, for example, gas and wind to work with both you at MIT and——

Mr. MONIZ. Possibly difficult relationship as opposed to marriage.

Senator HOEVEN. Exactly. But I think there's real opportunity if we can figure out how to drive it. I'm going to have my staff follow up with you, both of you on these issues——

Mr. MONIZ. We'd certainly be happy to work with your staff.

Senator HOEVEN. Thank you for coming today and for your testimony.

Again, Dr. Koonin, thank you for coming to North Dakota yesterday. Truly appreciate it.

Mr. KOONIN. It was great. Thank you.

The CHAIRMAN. Thank you both very much.

Let me just ask Dr. Koonin, maybe you would describe a little more. You said that there are individual policy studies or technology studies that accompany the technology review that you earlier released. Could you give us a little more information on those and when we might expect them?

Mr. KOONIN. Sure. There are 17 Technology Assessments that include analyses of the history, the technical potential, roadmaps for development, milestones and so on, for all of the usual suspects: nuclear, wind, biofuels and perhaps a few unusual ones.

They've been prepared by teams of people inside DOE in the national labs and peer reviewed by a set of independent external reviewers. They are all, more or less ready to go. We are in almost real-time discussions with OMB to get final clearance to post them up on the web. I would hope that that will come in the next day or 2. They're an integral part of the main report.

The CHAIRMAN. Very good. We congratulate you on the report and on the other studies as well, and, again, wish you well in your upcoming ventures.

Mr. KOONIN. Thank you. It's been a pleasure interacting with this committee in my current capacity, and there may be opportunities in the future——

The CHAIRMAN. Well, we appreciate your excellent work.

Mr. Moniz, we appreciate your excellent work, as always. Thank you both very much, and that'll conclude our hearing.

[Whereupon, at 11:29 a.m., the hearing was adjourned.]

[The following statement was received for the record.]

AMERICAN ENERGY INNOVATION COUNCIL,
November 15, 2011.

Hon. JEFF BINGAMAN,
*Chairman, Senate Committee on Energy and Natural Resources, 304 Dirksen, Wash-
ington, DC.*

Hon. LISA MURKOWSKI,
*Ranking Member, Senate Committee on Energy and Natural Resources, 304 Dirksen,
Washington, DC.*

DEAR CHAIRMAN BINGAMAN AND RANKING MEMBER MURKOWSKI: As chair of the American Energy Innovation Council (AEIC), I offer our support for S. 1703, the Quadrennial Energy Review Act of 2011, a bipartisan bill sponsored by Senator Mark Pryor, and S. 1807, the Energy Research and Development Coordination Act of 2011, sponsored by Senator Jeff Bingaman.

The AEIC is a group of America's top business executives who came together in 2010 to recommend ways to promote American innovation in clean energy technology. We are united in our belief that technology innovation—especially in energy—is at the heart of many of the central economic, national security, competitiveness, and environmental challenges facing our nation. As business leaders, AEIC members know firsthand how the private sector can be mobilized to attack these problems, but we also know the government must play a vital role in this process.

Since coming together, the AEIC has released two reports calling on a series of measures to bolster and improve our country's energy innovation capacity. Central among our recommendations is the need for the U.S. to develop a well coordinated National Energy Plan that can serve as an energy technology and policy roadmap. Importantly, such a plan should pinpoint key market failures and technology chokepoints in order to better orient federal programs and resources. To this end, AEIC strongly supports efforts to align, coordinate and improve the federal government's energy innovation activities. We support DOE's recent QTR process, which provided an important and meaningful first step toward developing a national energy strategy consistent with our own call for a National Energy Plan, and believe the federal government should move quickly toward a government-wide QER.

In the current era of fiscal austerity, it is paramount that federal programs are well designed, strategically coordinated, and streamlined—especially those related to energy innovation. The legislation being considered today implements a key AEIC recommendation and will help the country align and utilize federal resources related to the country's much needed energy innovation activities. The AEIC offers our full support for S. 1703 and S. 1807.

Sincerely,

CHAD HOLLIDAY,
*Chair, American Energy Innovation Council.
Chairman, Bank of America.*

APPENDIX

RESPONSES TO ADDITIONAL QUESTIONS

RESPONSES OF STEVEN E. KOONIN TO QUESTIONS FROM SENATOR MURKOWSKI

Question 1. One of the requirements of S. 1703, in establishing a Quadrennial Energy Review, is to assess policy options to increase domestic energy supplies. Based on your work with the Quadrennial Technology Review, would the Obama Administration include fossil fuels among the domestic energy supplies?

Answer. The Administration fully recognizes the role of fossil fuels in the nation's energy supply. That the Quadrennial Technology Review (QTR) respects this context is evident by the focus on infrastructure compatibility for new energy technologies.

The scope of the QTR is energy technology R&D supported by the Department of Energy. It does not address broader aspects of energy policy nor set priorities for energy R&D carried out elsewhere in government. Broader energy policy is discussed in the Blueprint for a Secure Energy Future. The QTR should be considered only one piece of what a larger Quadrennial Energy Review (QER) could look like. Such a QER could address detailed issues relevant to fossil resource extraction and the deployment of technologies to harness renewable resources alike.

Question 2. The QTR report states that the DOE is underinvested in the transport sector compared to the stationary sector, which suggests that the current Administration will seek to shift resources from stationary to transport. Which parts of the stationary sector do you see as being cut to increase investment in transport?

Answer. As we stated in the QTR, DOE focuses too much effort currently on researching technologies that are multiple generations away from practical use at the expense of analyses, modeling and simulation, or other fundamental engineering research that could influence private-sector, we also found that DOE is underinvested in activities supporting modernization of the grid (although the most critical advances needed for a modernized grid are not related to technology or R&D) and increasing building and industrial efficiency relative to those supporting the development of clean electricity. In identifying specific technologies for greater or less emphasis in the DOE portfolio including clean electricity technologies, we will assess their potential against our criteria of materiality, markets, and maturity (DOE QTR, pp. 106–109).

Question 3. the QTR states that DOE “will not support R&D on fuel pathways that have greater life cycle carbon emissions than conventional fuels” because the emissions from those fuels “outweigh the potential benefits for petroleum displacement.” What exactly is that analysis based on—did you conduct a cost-benefit analysis, or qualify the costs of climate change versus the benefits of reducing fuel imports?

Answer. Greenhouse Gas (GHG) emissions per unit of transportation fuel or electricity produced from various technologies and feedstocks are estimated using a series of technical calculations. since we are trying to make progress on three separate goals—economic growth, energy security, and environmental impacts—our decision criteria was that potential advances in pursuit of one goal should be balanced against potential impacts on either of the remaining two goals. In the case of technologies that convert a fossil fuel feedstock to liquid transportation fuels (e.g., coal-to-liquid or gas-to-liquid) in the absence of carbon capture and sequestration, the potential progress in the direction of energy security (alternative fuels to oil) may result in greater GHG emissions than traditional petroleum fuels.

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